Faculty of Arts & Science

Course Guide

GEOLOGY

Concordia
UNIVERSITY

REAL EDUCATION FOR THE REAL WORLD

DEPARTMENT OF GEOLOGY PROGRAM

COURSE GUIDE 1994-95

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This course guide has been prepared months in advance of the current academic year and information contained is subject to change.

Students are advised not to purchase texts without the approval of the professor concerned.

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WHAT IS GEOLOGY

Geology is the scientific study of the planet Earth. The basic principles of geology learned on earth, have also been vital in the effort to understand the Solar System.

Study of rocks, minerals and fossils..., processes that shape the Earth's surface and operate in its interior..., the magnetic and other radiation fields of Earth..., landslides, earthquakes and their prediction..., soil formation, erosion and conservation..., effect of man's activities on the Earth's environment..., metal, fuel and water resources, their search, use and conservation..., sites for roads, dams and buildings..., ocean floors and mountain chains..., surface features of the Moon and other planets..., all this and more is geology.

The scope of geology is too broad for any one scientist, therefore, most geologists specialize in one or more facets of geology, in much the same way as engineers specialize in various fields of physical science such as electronics and construction. To mention a few specialities: those who study minerals and rocks need specialized training in chemistry and physics, as do the geochemists who are concerned with chemical process in the Earth; those who study fossils must be trained in biology of plants and animals so that they can interpret the age and environment of ancient life forms; those who study deformed rocks must know mechanics, and groundwater and petroleum geologists must be familiar with fluid dynamics. These specializations in geology, are usually emphasized at the graduate level. At the undergraduate level, however, students can, with the help of faculty, select their electives with a particular field and specialization in mind.

GEOLOGY TODAY

Geology has started off the 1980s with a bang, both literally and figuratively. Explosive eruptions from Mt. St. Helens and from other volcanoes, severe earthquakes: droughts, floods and disastrous slope failures; exciting discoveries from direct observations of the deep-sea floor and from images of the outer planets of the solar system are big news. At the same time, the end of the era of abundant and cheap energy from fossil fuels and the widespread realization that man's meddling with Nature is beginning to produce long-term and perhaps irreversible deterioration of the environment has forced on every citizen the importance of knowing how the Earth works. Furthermore, the search for ever more elusive mineral and hydrocarbon deposits, the estimation of potential resources, the devising of sound environmental practices, all require progressively more sophisticated practice of geology. So, too, does a continuing assessment of the ability of the Earth's environment to sustain our edifices and to contain our wastes. The knowledge of geologists is needed more urgently and in more ways than ever before.

Geology, as a science, has undergone a major transition during the last three decades and continues to evolve rapidly. What was largely an observational and descriptive discipline has, in addition, changed into a largely quantitative, experimental and predictive science. During this period of change

advanced concepts of physics, chemistry and mathematics have been applied to solve geological problems which have previously resisted solution. The scientific study of the Earth has thus taken on a broader scope, embodying sub-disciplines such as geophysics and geochemistry and is now referred to as Earth Sciences or Geosciences.

WHAT GEOLOGISTS DO

In pursuing a discipline that is so varied and so large in scope, geologists engage in many kinds of activities. Field work may be a major part of their study in which results have to be compiled in the office and reports written about the results. This kind of work is centered around libraries. Much geological work is also done in the laboratory using various sophisticated equipment. Some geologists study natural processes, both in the field and in the laboratory. The main work of one group of geologists consists entirely of theorizing. The following are samples of some of the things geologists do:

- mapping on a regional scale the still unmapped parts of the Canadian Arctic Islands
- study, in a laboratory, properties of rocks and minerals at high pressure and high temperature
- SCUBA diving to study coral reefs off Barbados
- surveying on mule-back or helicopter the mineral potential of mountainous areas in Australia or South America
- exploring for water in an arid region
- working as a member of a UN mission to field study an earthquake stricken area in Turkey
- interpreting by means of satellite images the geology of vast, inaccessible regions
- deciding if and where subsurface mining should be extended
- studying the ocean floor off Galapagos Islands
- investigating the effects of acid rain in southern Ontario
- investigating the origin of the Earth's magnetic field
- teaching in school or teaching and research at university
- advising a government on its mineral and energy policies
- working in co-operation with engineering groups in the design of major-hydroelectric construction projects

EMPLOYMENT OPPORTUNITIES

Prior to the current period, employment opportunities for new graduates in geology were excellent. Forecasters on future outlook are optimistic that opportunities for employment will be sustained at a high level well beyond the year 2000. The employment situation is far from buoyant at the present time but is still better than in other areas of natural sciences. The principal employers are: federal and provincial geological surveys, government research institutes, companies engaged in oil and mineral exploration and engineering works, the United Nations and U.N. sponsored agencies, universities and schools. Some geologists practice their profession as consultants.

OBJECTIVES OF THE GEOLOGY DEPARTMENT

The continuing objective of the Geology department is to offer the best undergraduate education in geology; best in the quality of the programmes, in the quality of teaching and facilities and in the quality of interaction between students and faculty members.

FULL-TIME FACULTY AND THEIR FIELDS OF INTEREST (in 1993-94)

A.E. Abdel-Rahman, PhD (McGill), Assistant Professor
Igneous Petrology, Mineralogy, Geochemistry and Regional Tectonics

C. Elliott, PhD (Univ. of New Brunswick), Assistant Professor
Structural Geology

J.T. Jenkins, MSc (McGill), Associate Professor
Crystal Chemistry, Mineralogy, Igneous and Metamorphic Petrology

P.S. Kumarapeli, PhD (McGill), Professor
Tectonics, Geophysics

K.K. Mukherji, PhD (Univ. of Western Ontario)
Associate Professor and Chair
Carbonate Petrology, Sedimentation

J. Patterson, PhD (Virginia Polytechnic Institute and State University)
Assistant Professor
Environmental Geology

G.P. Sassano, PhD (Univ. of Alberta), Associate Professor
Economic Geology and Mineral Deposits

ADJUNCT PROFESSOR (in 1993-94)

Dr. D.J. McDougall, PhD, McGill University
Dr. K. St. Seymour, PhD, McGill University

STAFF (in 1993-94)

L. Bertrand
M. Kwiatkowski

FACULTY RESEARCH

The faculty members have carried out geological work in various parts of Canada, U.S.A., the Alps, the Near East, Middle East, India, Sri Lanka and in South America. Current research activities are concentrated in the Quebec Appalachians, Spain, Italy and the Canadian Shield.

FACILITIES

In addition to general facilities and services such as the libraries and the computer centre provided by the university, the Department maintains well-equipped laboratories with adequate study collections of minerals and rocks including thin and polished sections for microscopic studies, fossils, maps and air photos. The Department also has its own X-ray diffraction, SEM and cathodoluminescence equipment, geophysical equipment, fluid inclusion thermometry equipment, and facilities for the preparation of material for laboratory study. Access to other analytical facilities as Atomic Absorption and X-ray fluorescence equipment is available from other departments. Two vehicles are available for field trips.

STUDENT PARTICIPATION

The Concordia Geology Club, run exclusively by students has reasons to be proud of its record. Activities include sponsoring guest lectures, organizing field trips, preparing and manning exhibits at the annual Science week at Concordia University and at the Prospectors and Developer's Convention in Toronto, inviting through its job committee, prospective employers to the campus to interview students for summer as well as permanent employment and organizing several social events including the Spring party. Upper year students with above average academic records are provided the opportunity of getting teaching experience through demonstration in laboratory classes. A stipend is paid for this work.

SCHOLARSHIPS, FINANCIAL AID, AWARDS, MEDALS AND PRIZES

Scholarships and prizes are given in recognition of outstanding academic achievements. The Andre Deland Medal for Geology is awarded annually, when merited, to the graduating student with the highest standing in geology. Two annual awards are given by the Canadian Society of Petroleum Geologists to undergraduates who have demonstrated outstanding competence in fields related to petroleum geology. The Department awards a prize to a second year student who maintains the highest grades. The Mineralogical Association of Canada also gives an annual award. For information on bursaries students are advised to refer to the Office of the Dean of Students.

SUMMER EMPLOYMENT

Students are urged to make every effort to obtain summer employment with geological field parties. In addition to obvious financial benefits, these jobs provide valuable field experience. Student Job Committee as well as the Department invite prospective employers to the Campus but the task of job procurement is the responsibility of students. Federal and Provincial geological surveys and companies involved in mineral and oil exploration are the principal employers. Summer employment opportunities for students usually follow economic trends.

PRE-UNIVERSITY EDUCATION FOR GEOLOGISTS

Students contemplating a career in Geology should acquire a strong background and interest in the basic sciences and mathematics in their pre-university education. They will also need an enquiring and open mind, an ability to grasp fundamental scientific principles quickly and easily and to communicate ideas clearly. They must be able to apply the basic principles of chemistry, physics, biology and mathematics and to use deductive reasoning to solve complex geological problems.

GEOLOGY PROGRAMMES

The Department offers a total of eight programmes. Four are in Geology at different levels of concentration: Honours, Specialization, Major and Minor. Out of the 90 credits necessary for a B.Sc. and normally taken over a 3-year period, the programmes specify 69 credits for Honours; 63 credits for the Specialization, 39 credits for the Major and 24 credits for the Minor. The remaining four programmes are geology-based interdisciplinary programmes aimed at preparing students who wish to follow careers in some of the sub-disciplines of Earth Sciences. These are at the Specialization level: one with Physics (83 credits) to prepare students who wish to follow careers in geophysics through subsequent job training or graduate studies, a second with chemistry (82-83 credits) to provide background preparation for students who wish to pursue careers in geochemistry, a third with geography aimed at students who wish to pursue careers in the evaluation and management of earth resources (78 credits) and a fourth combines geology with ecology (78 credits).

Students with professional aspiration should register in the Specialization programmes. These programmes are designed for professional development and provide balanced sequences of courses in both theoretical and practical aspects. Students entering the Specialization in Geology can later change into the Honours programme in Geology, provided their grades are sufficiently high. The Honours programme provides the best all around preparation for those who wish to pursue graduate studies and research in geology.

The Major programme is aimed at the generalist. It does not provide sufficient preparation for students to function as professional geologists.

Lectures and laboratory work cannot successfully substitute for actual observation and study of geology in the field. Therefore, our department conducts many field trips to areas of geological interest as parts of courses. Within an hours drive from the University students can observe late Precambrian metamorphic and intrusive rocks; Paleozoic undeformed and folded sedimentary rocks; Cretaceous intrusives and glacial, marine and fresh water unconsolidated Pleistocene and Recent deposits. In addition, two field schools (Geol. 216, Geol. 316) are conducted by the staff for two weeks in May following the Spring exams.

BSc. Honours in Geology (63 crs.in Geology + 6 crs.in other courses)

Year I

210^3 - Physical Geology
211^3 - Mineralogy I
212^3 - Invertebrate Paleontology
213^3 - Structural Geology I
216^3 - Field Methods
231^3 - Physics of the Earth

Year II

311^6 - Introductory Petrology
313^3 - Optical Crystallography
314^3 - Stratigraphy
316^3 - Field Geology
318^3 - Structural Geology II
331^3 - Historical Geology
332^3 - Economic Geology

Year III

411^6 - Igneous and Metamorphic Petrology
413^3 - Sedimentary Petrology
414^6 - Undergraduate Research
415^3 - Plate Tectonics & Crustal Evolution
417^3 - Mineral Deposits

in addition: Comp. 212^3 or equivalent; 3 credits chosen from Biol. 322^3, Geog. 362^3 or Math 242^3

BSc. Specialization in Geology (57 crs. in Geology + 6 crs. in other courses)

Year I

210^3 - Physical Geology
211^3 - Mineralogy I
212^3 - Invertebrate Paleontology
213^3 - Structural Geology I

216[3] - Field Methods
231[3] - Physics of the Earth

Year II

311[6] - Introductory Petrology
313[3] - Optical Crystallography
314[3] - Stratigraphy
316[3] - Field Geology
318[3] - Structural Geology II
331[3] - Historical Geology
332[3] - Economic Geology

Year III

411[6] - Igneous and Metamorphic Petrology
413[3] - Sedimentary Petrology
415[3] - Plate Tectonics & Crustal Evolution
417[3] - Mineral deposits

In addition: Comp. 212[3] or equivalent;

3 credits chosen from Biol. 322[3], Geog. 362[3] or Math 242[3]

BSc. Specialization in Geology-Physics (45 crs.in Geology, 32 crs in physics, 6 crs.in Math)

Year I

Geol. 210[3] - Physical Geology
211[3] - Mineralogy I
212[3] - Invertebrate Paleontology
213[3] - Structural Geology I
Phys. 232[3] - Theoretical Physics I
243[3] - Classical Mechanics I
253[3] - Electricity & Magnetism I
254[3] - Electricity & Magnetism II
Math. 262[3] - Advanced Calculus I
263[3] - Advanced Calculus II

Years II & III

Geol. 216[3] - Field Methods
231[3] - Physics of the Earth
311[6] - Introductory Petrology
331[3] - Historical Geology
332[3] - Economic Geology
415[3] - Plate Tectonics & Crustal Evolution
422[3] - Exploration Geophysics

Phys. 291[1] - Experimental Mechanics I
293[1] - Experimental Electricity and Magnetism I
295[2] - Experimental Electronics I
334[3] - Thermodynamics
364[3] - Atomic Physics

In addition:

9 credits chosen from Geol. 232[3] and Geol. 300- and 400-level courses.
10 credits chosen from Phys. 244[3], 252[3], 292[1], 294[1], 297[1], 335[3], 336[3] 393[1], 394[1], 465[3], 495[1]

Specialization in Geology-Chemistry (45 crs. in Geology, 34-35 crs. in Chemistry, 3 crs. in Computer Science)

Year I

Geol. 210[3] - Physical Geology
211[3] - Mineralogy I
212[3] - Invertebrate Paleontology
213[3] - Structural Geology I
216[3] - Field Methods
Chem. 217[3] - Analytical Chemistry I
218[3] - Analytical Chemistry II
241[3] - Introduction to Inorganic Chemistry
242[3] - Chemistry of the Main Group Elements
Comp. 212[3] - Introduction to Computers and Computing

Years II & III

Geol. 231[3] - Physics of the Earth
311[6] - Introductory Petrology
331[3] - Historical Geology
332[3] - Economic Geology
415[3] - Plate Tectonics & Crustal Evolution
Chem. 231[2] - Physical Chemistry I: Introduction
232[2] - Thermodynamics
233[2] - Physical Chemistry II: Spectroscopy & Quantum Theory
290[3] - Laboratory Automation and Data Handling
312[3] - Intermediate Analytical Chemistry
338[2] - Physical Chemistry Laboratory I
341[3] - Inorganic Chemistry III: The Transition Metals

in addition:

12 credits chosen from Geol. 232[3], 313[3], 411[6], 417[3],
5-6 credits chosen from Chem. 221[3], 222[3], 339[2], 398[3], or 498[3]

BSc. Specialization in Resource Analysis and Land Use (45 crs. in Geology, 27 crs. in Geography, 6 crs. in Political Science or 12 crs. in Economics)

Year I

Geol. 210^3 - Physical Geology
211^3 - Mineralogy I
212^3 - Invertebrate Paleontology
213^3 - Structural Geology I
216^3 - Field Methods
231^3 - Physics of the Earth
Geog. 211^6 - Introduction to Human Geography
267^3 - Introductory Cartography

Years II & III

Geol. 311^6 - Introductory Petrology
331^3 - Historical Geology
332^3 - Economic Geology
415^3 - Plate Tectonics & Crustal Evolution
Geog. 303^3 - Human-Environment Relations: A Framework for Analysis
317^3 - Population Geography
355^3 - Resource Management
372^6 - Analysis of the Environment
475^3 - Hydrology I

in addition:

12 credits chosen from Geol. 232^3 and Geology 300- and 400-level courses.
6 credits chosen from either Poli 361^3, 363^3, OR *Econ. 391^3, 396^3.

*Requires prerequisites of Econ. 201^3, Econ. 203^3

BSc. Specialization in Geology-Ecology (45 crs. in Geology, 33 crs. in Biology)

Year I

Geol. 210^3 - Physical Geology
211^3 - Mineralogy I
212^3 - Invertebrate Paleontology
213^3 - Structural Geology I
Biol. 230^3 - Animal Biology
240^3 - Plant Biology
250^3 - Fundamentals of Ecology
270^3 - Introductory Microbiology

Years II & III

Geol. 216^3 - Field Methods
224^3 - Introduction to Remote Sensing and Terrain Analysis
231^3 - Physics of the Earth
311^6 - Introductory Petrology
331^3 - Historical Geology
332^3 - Economic Geology
415^3 - Plate Tectonics & Crustal Evolution
Biol. 322^3 - Biostatistics 1
344^3 - Biology of Algae
352^3 - Plant Field Ecology
355^3 - Fundamentals of Limnology
359^3 - Evolutionary Biology
OR
381^3 - Biology of Pollutants

in addition:

9 credits chosen from Geol. 232^3 and Geol. 300- and 400- level courses
3 credits chosen from Biol. 321^3, and 454^3.
3 credits chosen from Biol. 356, 358, 381 (if not chosen above), 398A, 452, 453, or 456

BSc. Major in Geology (39 crs. in Geology)

Year I

Geol. 210^3 - Physical Geology
211^3 - Mineralogy I
212^3 - Invertebrate Paleontology
213^3 - Structural Geology I
216^3 - Field Methods
231^3 - Physics of the Earth

Years II & III

Geol. 311^6 - Introductory Petrology
331^3 - Historical Geology
332^3 - Economic Geology
415^3 - Plate Tectonics and Crustal Evolution

in addition:

6 credits chosen from Geol. 232^3 and Geol. 300- and 400-level courses.

Minor in Geology (24 crs. in Geology)

Geol. 210^3 - Physical Geology
211^3 - Mineralogy I

212[3] - Invertebrate Paleontology
213[3] - Structural Geology I

in addition: 12 geology elective credit value

NOTE:

1. The superscript denotes the credit value
2. Geology 210[3] and 211[3] do not require any prerequisites.
3. Geology 203[3], 205[3], 206[3], 207[3], 208[3], may be taken by students with no previous background in geology, but may only be claimed as geology credits by students in the Minor Geology program
4. Students with CEGEP geology 901 may be exempted from Geol. 210

GEOLOGY 203/2

INTRODUCTION TO ENVIRONMENTAL GEOLOGY (3 credits)

Professor: G.P. Sassano Lec. 51 M 19:00-21:05 (Loyola)

Description: A course designed for the student with no previous background in geology who is interested in the geological problems related to the environment. A study will be made of the planet as a closed system with limited resources. Areas of concentration will be: the physical processes and the environment including landscape evolution; the geological cycles including weathering, erosion, transportation and deposition; geological hazards related to rivers, landslides, earthquakes, volcanoes, coasts; the interaction between man and the environment including the long range effects of ecosphere pollution; the understanding of control for and prevention of natural hazards; proper land use and landscape evaluation; the role of geology related environmental laws. Lectures only.
Note:Geology students in Honours, Specialization or Major programmes may not take this course for geology credits.

Prerequisite: No previous background in geology required.

Text: Environmental Geology. E.A. Keller, Merrill
Environmental Science, P.U. Purdom, S.H. Anderson, Merrill

Assignments & Grading:

Term tests	45%
Final exam	55%

GEOLOGY 205/4

NON-RENEWABLE RESOURCES (3 credits)

Professor: G.P. Sassano Lec. XX J 18:05-20:10 (SGW)

Description: This course is designed for the student with no previous background in Geology. The course will deal with the past, present and future availability of natural resources considering social needs, consumption patterns and future supply and demands of land, base metals, energy, industrial minerals, fossil fuels, water, and other resources. Concepts related to exploration, development and rational exploitation of resources will be examined keeping in mind the nature, classification and mode of occurrence of mineral deposits and their world distribution patterns. Some lectures will also be dedicated to concepts related to the production and exploitation of hydro and geothermal power and to nuclear, wind and solar energy. Lectures only.
Note: Students in degree programmes in geology may not take this course for credits.

Prerequisites:
No previous background in geology required.

Texts: - Earth Resources, B. Skinner, Prentice Hall
- Earth Bound, C.F. Park, Freeman
- Our Finite Mineral Resources, S.E. Kesier, McGraw Hill
- Mineral Resources, J.A. Wolfe, Chapman and Hall

Assignments & Grading:

Term test	50%
Final exam	50%

GEOLOGY 206/4

EARTHQUAKES, DRIFTING CONTINENTS AND VOLCANOES (3 credits)

Professor: J. Patterson Lec. 51 W 19:00-21:05 (Loyola)

Description: Since the very beginning man has had an inborn and ever increasing curiosity about the meaning and origin of natural phenomena, and catastrophic ones in particular. This urge to explain their origin and therefore to predict and possibly to react to them has resulted in a vast accumulation of facts and knowledge about volcanoes, earthquakes and continental motions. In the late sixties and early seventies, earth scientists, in a world-wide effort of cooperation, have concluded almost spontaneously that most global events are interrelated, and that they are due to the tendency of an ever-changing earth to establish a state of mobile equilibrium. Gone are the days that stressed permanency of continents and oceans. The course will examine the distribution patterns of large-scale earth phenomena and explore their cause

and effect relationships. (Lectures only).

Note: Geology students in degree programmes may not take this course for credit.

Prerequisite:
No previous geological background required.

Texts: Inside the Earth, B. Bolt, Freeman; Volcanoes and Earthquakes, G.Oakeshott, McGraw-Hill; Continents Adrift and Continents Aground, Freeman.

Assignments & Grading:

1st test	10%
2nd test	10%
Review questions and/or term paper	20%
Final examination	60%

GEOLOGY 208/2

THE EARTH, MOON AND THE PLANETS (3 credits)

Professor: G.P. Sassano Lec. XX W 18:05-20:10 (SGW)

Description: "We have walked on the moon and seen beneath the clouds of Venus. And we are all parts of this venture. For thousands of years, people have gazed-up at our satellite and seen those familiar man-in-the moon features that perpetually face our planet. Yet we were alive when humanity first saw the hidden side of the moon.....We live in a time of adventure and exploration on the grandest scale." William J. Kaufmann III.

The course emphasizes the cosmic perspective of the Earth and focuses attention on how the results of the last two decades of planetary exploration have brought about an intellectual revolution concerning the planets, especially their surface features, processes and histories. Lectures only.
Note: Geology students in degree programmes may not take this course for credits.

Prerequisites:
No previous background in earth and planetary sciences is required.

Texts: - Planets, Bruce Murray, Freeman
- Planets and Moons, William J. Kaufmann III, Freeman
- Earth-like Planets, B. Murray, M. Malin and R. Greenly, Freeman

Assignments & Grading:

Mid Term	50%
Final Examination	50%

GEOLOGY 210

PHYSICAL GEOLOGY (3 credits)

First Term /2

Professor: J. Patterson
Lec. 01 TJ 10:15-11:30 (Loyola)
Lab. 01 T 14:00-17:00 (Loyola)

Second Term /4

Professor: A. Abdel-Rahman
Lec. 51 M 19:00-21:05 (Loyola)
Lab. 51 T 18:30-21:30 (Loyola)

Description: The purpose of the course is to provide an introduction and overview of the physical aspects of the planet Earth. Topics that are covered include: origin of the solar system and earth; differentiation of the earth; evolution of the atmosphere; rocks and minerals; volcanism; geologic time; seismology, gravity and the earth's interior; the earth's magnetic field; and surface processes, including weathering and glaciation. The course culminates with the theory of plate tectonics. Time permitting, the geology of Canada is examined. Laboratory work includes the identification of rocks and minerals, and exercises in working with maps. There is a field trip to Mount Royal.

Prerequisites: No previous background in geology is required.

Texts:
/2 - Earth, Press and Siever, 4th Edition
/2 - Exercises in Physical Geology, Hamblin & Howard, 8th Edition
/4 - Physical Geology, "Earth Revealed", Megeary & Plummer, W.C. Brown

Assignments & Grading:

Laboratory work	30%
Mid-term test	25%
Final exam	45%

GEOLOGY 211/4

MINERALOGY I (3 credits)

Professor: J.T. Jenkins
Lec. 01 WF 10:15-11:30 (Loyola)
Lab. 01 M 14:00-17:00 (Loyola)

Description: Physical and chemical properties of minerals, Crystallography, crystal notation, stereographic projection. Crystal structures. Identification, description and classification of minerals. Lectures and laboratory.

Prerequisites: No previous background in geology is required, but CEGEP-level chemistry is strongly recommended.

Texts: Hurlbut, Dana's Manual of Mineralogy, 20th ed. John Wiley & Sons

Materials: Land Lens, small penknife

Recommended Reference:

a) Deer, Howie and Zussman. Introduction to Rock Forming Minerals. Longmans (paper-back, 1956).

b) Bloss, F.D. Crystallography and Crystal Chemistry, Holt, Rinehart & Wintson, 1971.

c) Fleischer, M. Glossary of Mineral Species. Mineralogical Record Inc., 1960.

Assignments & Grading:

Lab. Report	25%
Periodic lab tests & final lab test	25%
Final examination	50%

GEOLOGY 212/4

INVERTEBRATE PALEONTOLOGY (3 credits)

Professor: K.K. Mukherji

Lec. 01 TJ 11:45-13:00 (Loyola)
Lab. 01 T 14:00-17:00 (Loyola)

Description: A systematic survey of major invertebrate fossil groups with emphasis on morphology, classification and geologic occurrence. Study of principles of evolutionary concepts and zonation. Some selected discussion on paleoecology. Lectures and laboratory.

Prerequisites: Geol. 210 or equivalent

Texts: Fossil Invertebrates, Boardman, R.S., Cheetham, A.H. and Rowell, A.J. BSP

Assignments & Grading:

Students must attend at least 80% of lecture and lab. sessions. Students must secure a definite passing grade in lab. and theory sections separately.

Laboratory assignments	40%
Final examination	60%

Examination materials include lecture topics, handouts and special reading assignments. Students may also be required to attend field trips and write reports.

GEOLOGY 213/4

STRUCTURAL GEOLOGY I (3 credits)

Professor: C. Elliott

Lec. 01 WF 11:45-13:00 (Loyola)
Lab. 01 J 14:00-17:00 (Loyola)

Description: All rocks have structure: They all have distribution and geometry, and they contain features acquired during rock formation and/or deformation. Structural Geology I is an introduction to the recognition and significance of such primary and secondary structures. Emphasis will be placed in the course on classification and nomenclature, and on the observation of structure on maps and in the field.

The labs will concentrate on reading and interpreting maps, and on descriptive geometry and stereographic methods for analyzing structural data.

Prerequisites: Geol. 210 or equivalent

Texts: Structural Geology of Rocks and Regions, G.H. Davis

Assignments & Grading:

Midterm	15%
Laboratory assignments	30%
Final Laboratory exam	20%
Final lecture exam	35%

GEOLOGY 216/4

FIELD METHODS (3 credits)

Professor: S. Kumarapeli

Lec. 01 J 10:15-11:30

Description: One lecture per week in the winter term will be followed in the Spring by a two-week field school, immediately after the final examinations in May. The lectures will deal with elements of surveying and preparation of base maps, description and recording of geological field data, construction of geological maps, collection and presentation of geophysical and geochemical field data.

During the field school, students working in groups will carry out field exercises in surveying, geological mapping, geophysical and geochemical surveys of selected sites. Transportation to work sites will be provided. Students must provide their own notebooks, hand lenses and safety glasses.
The period of the field school is a total work immersion period and students should be prepared not only for early starts but also to work late into the evenings in order to process and plot their field data on a daily basis. Report for each activity is to be submitted.

Prerequisites: Geol. 213, 231

Text: T.B.A.

Assignments & Grading:

Written examinations based on lectures and reading assignments 15%

Field work performance	30%
Field data and report presentation	30%
Examination on field exercises	25%

GEOLOGY 224/2

INTRODUCTION TO REMOTE SENSING AND TERRAIN ANALYSIS (3 Credits)

Professor: A. Abdel-Rahman

Lec. 01	MW	13:15-14:30	(Loyola)
Lab. 01	M	15:00-18:00	(Loyola)

Description: Lectures introduce the student to the development and application of remote sensing techniques including aerial photography, airborne magnetometer data, aerial thermography, side looking aerial radar and multi-spectral scanning imagery from satellites. Emphasis is placed on geological and geographical application of terrain analysis. In the laboratory several kinds of remote sensing data will be coupled with bed rock and Quaternary maps in the analysis of selected areas.

Prerequisites:
Geology 210, or Geography 271, or permission of the Department. Students will find it helpful if they have previously taken Geol. 213 and Geol. 311 previously or concurrently.

Text: Guide to Remote Sensing, S.A. Drury, Oxford University Press

Assignments & Grading:

Mid term examination	30%
Final examination and project	45%
Laboratory and project	25%

GEOLOGY 231/2

PHYSICS OF THE EARTH (3 credits)

Professor: S. Kumarapeli

Lec.	WF	8:45-10:00	(Loyola)
Lab.	W	14:00-17:00	(Loyola)

Description: This course is directed toward the general understanding of physical phenomena of the solid Earth. Subjects for consideration include the following: earth's origin, age, radioactivity, magnetism, gravity field, seismology, heat flow and the structure and physical state of the Earth's interior. Lectures and Laboratory.

Prerequisites: CEGEP Math 103, 203; Phys. 301, Geol. 210 or equivalent.

Text: Geophysical Methods in Geology, P.V. Sharma, Elsevier

Assignments & Grading:

Laboratory examinations	40%
Theory examinations	60%

GEOLOGY 232/4

INTRODUCTION TO GEOCHEMISTRY (3 credits)

Professor: A. Abdel-Rahman

Lec. 51	T	18:05-20:10	(Loyola)
Lab. 51	W	18:30-21:30	(Loyola)

Description: The course will focus on the application of concepts of elementary chemistry to geological problems. Subjects for consideration include: application of thermodynamics to geological problems, phase equilibria relationships in petrogenesis, partitioning of elements, crystal chemistry, distribution of elements, chemistry of natural waters including properties of water at high temperature and pressures. Lectures and Lab.
Note: Students who have credit for Geol. 222 may not take this course for credits.

Prerequisites: CEGEP Chemistry 201, Physics 301, Mathematics 103, 203; Geol. 210.

Text: T.B.A.

Assignments & Grading: T.B.A.

GEOLOGY 298C/4

ENVIRONMENTAL CHANGE IN GEOLOGY

Professor: J. Patterson Lec. 51 19:00-21:05 (Loyola)

Description: Understanding environmental change is an important challenge facing the global community today. It is the purpose of this course to provide the student with knowledge of the physical and historical aspects of change occurring to the planet. The course will focus on the basics of the planet, how it works, and the nature of the changes that have occurred in the past, are presently occurring, and those which may occur in the future.

Topics to be covered include:
- formation and early development of the earth
- evolution of the atmosphere
- the evolution of life and its influence on the atmosphere and land surface processes
- plate tectonics as it pertains to tectonic influences on climate (e.g. monsoons)
- volcanoes and climate
- the earth's global heat budget, including the role radiatively active gases (the greenhouse effect)

- the carbon cycle
- the record of atmospheric and climatic change from rocks, deep ocean sediments and ice cores
- present changes to the atmosphere, and trends in these changes
- patterns of production and consumption of energy

Prerequisites:
There are no pre-requisites. Note: Students in degree programmes in Geology may not take this course for Geology credits.

Textbook: Environmental Chemistry, Nigel Brunce, Wuerz Publishing

Assignments & Grading:

Mid Term	25%
Term Paper	30%
Final	45%

GEOLOGY 311/3

INTRODUCTORY PETROLOGY (6 credits)

Professor: J.T. Jenkins & A. Abdel-Rahman

Lec. 01 TJ 08:45-10:00 (Loyola)
Lab. 01 F 14:00-17:00 (Loyola)

Description: The identification and description of hand specimens of igneous, sedimentary and metamorphic rocks. Study of rock associations, classification and origin of major rock groups. Lectures and laboratory.

Prerequisites:: Geol. 211

Texts: None. This course draws on many sources for its materials, and there are many recommended references, some of which serve as texts in other courses.

a) Winkler, H.G.F. Petrogenesis of the Metamorphic Rocks, 5th ed., Springer Verlag, 1979.
b) Spry, A. Metamorphic Textures, Pergamon 1969.
c) Travis Russell. Classifications of Rocks, Colorado School of Mines Quarterly, vol. 50, 1955, reprinted 1992.
d) Ehlers, E.G. and H. Blatt. Petrology, W.H. Freeman & Co., 1982.
e) Greensmith, J.T. Petrology of the Sedimentary Rocks, 6th ed. George Allen and Unwin, 1978.

Assignments & Grading:

Weekly reports in labs	25%
Three sectional lab exams	25%
Final exam	50%

GEOLOGY 313/2

OPTICAL CRYSTALLOGRAPHY (3 credits)

Professor: J.T. Jenkins
Lec. 01 WF 10:15-11:30 (Loyola)
Lab. 01 J 14:00-17:00 (Loyola)

Description: Behaviour of light in crystals. The optical indicatrix. The polarizing microscope and optical properties of minerals. Identification of non-opaque minerals in oil immersion and thin sections. If time permits use of the Universal Stage will be introduced. Lectures and laboratory.

Prerequisites: Geol. 211

Texts: a) either: F.D. Bloss. An Introduction to the Methods of Optical Crystallography. Holt, Rinehart, Winston, 2nd ed. 1974.
or
E.E. Wahlstrom. Optical Crystallography, 5th ed., John Wiley & Sons, 1976.

b) A Laboratory text will be recommended.

Assignments & Grading:

Weekly laboratory assignments	25%
Laboratory exam	25%
Final exam	50%

GEOLOGY 314/2

STRATIGRAPHY (3 credits)

Professor: K.K. Mukherji
Lec. 01 WF 11:45-13:00 (Loyola)
Lab. 01 M 14:00-17:00 (Loyola)

Description: Introduction to historical developments of stratigraphic concepts. Role of natural dynamic processes in the evolution of stratigraphic record. Discussion on stratigraphic classification and nomenclature. Major classification of tectonic elements in sedimentary basins and broad patterns in the distribution of sedimentary rocks in relation to tectonic framework. Detailed analysis of stratigraphic principles such as correlation (lithostratigraphic, biostratigraphic, chronostratigraphic) facies (lithofacies, biofacies), unconformities and cyclothem. Critical evaluation of stratigraphic sequences using modern and ancient examples for the recognition of aeolian, alluvial fan, fluvial, lacustrine, tidal flats, barrier coastlines, carbonate shore line, shallow marine and submarine environments. Lectures and laboratory.

Prerequisites: Geol. 212 and 311 previously or concurrently.

Texts:

Principles of Sedimentology and Stratigraphy, Boggs, Sam., Merrill.
Reading, H.D. Sedimentary Environments and Facies. Elsevier.
Dunbar, C.G. and Rodgers, J. Principles of Stratigraphy. John Wiley & Sons.

Assignments & Grading:

Students must attend at least 80% of lecture and lab sessions. Students must obtain a definite passing grade in theory and lab sections separately.

Final exam	50%
Laboratory assignments and field reports	50%

Examination materials include lecture topics, handouts, special reading assignments. Students must attend field trips and submit reports.

GEOLOGY 316/4

FIELD GEOLOGY II (3 credits)

Professor: C. Elliott

Description: This will be a two-week field school following immediately after final examinations in May. It will involve mapping in a poly-deformed area, focusing on the recognition of rocks and structures in the field, the collection and recording of geological data, and on building a coherent and rational picture of the local and regional geology and geological history.

Students will work in pairs for mapping and stereographic plotting of structural data. At the end of the two weeks each pair will hand in a geological map, an interpretation map, cross sections and/or block diagrams, and all relevant stereographic plots. Each pair will present orally their interpretation of the geology and geological history of their map areas. They will be expected to justify conflicts between their data and interpretations and those of students mapping in adjacent areas.

The Department will provide instructors, transportation, compasses and maps. Students must pay for their food and lodging, and must provide their own hammers, hand lenses, safety glasses, map boards, notebooks, and stereonets.

Recommended text:

The mapping of Geological Structures, K. McClay

Assignments & Grading:

Field work and performance	20%
Final geological map and stereoplots	50%
Interpretation maps, sections and block diagrams	20%
Oral presentation	10%

Prerequisites: Geol. 216; Geol. 311

GEOLOGY 318/2

STRUCTURAL GEOLOGY II (3 credits)

Professor: C. Elliott

Lec. 01 TJ 8:45-10:00 (Loyola)
Lab. 01 J 14:00-17:00 (Loyola)

Description: While Structural I focused on the descriptive aspects of structural geology, this course looks more closely at the processes and results of deformation. It will begin with a survey of stress, strain, and ideal material behaviour, and go on to examine deformation structures and the deformation mechanisms which created them. The processes of folding, cleavage and lineation development, and faulting will be studied, as will the practical aspects of mapping and map interpretation. The culmination of the course will be an overview of structural associations and tectonic regimes.

The laboratory exercises will involve advanced structural analysis through descriptive geometry, stereographic projections, and block diagrams.

Prerequisites: Structural I (Geol. 213)

Text: Structural Geology of Rocks and Regions, G.H. Davis

Assignments & Grading:

Mid-term exam	30%
Final exam	40%
Laboratory exercises	20%
Laboratory test	10%

GEOLOGY 331/4

HISTORICAL GEOLOGY (3 credits)

Professor: S. Kumarapeli

Lec. 01 WF 8:45-10:00 (Loyola)
Lab. 01 J 14:00-17:00 (Loyola)

Description: The Earth has undergone profound changes during its 4.6 billion years of existence as a dynamic planet. Its store of internal energy, following an early peak, has decreased progressively. The size, shape and geographic distribution of continents have changed through time. Its early atmosphere, from which the present one evolved, is thought to have consisted of carbon dioxide, water vapour, nitrogen, some reduced gases, but only traces of free oxygen. Such an atmosphere and oceans seem to have been present when microbial life arose in the seas about 3.5 billion years ago. Historical geologists seek to determine the changes that all aspects of the Earth have undergone, place them in a chronological sequence and provide a conceptual framework for explaining such changes. To do this, there are some well established

guiding principles which were discovered by the founders of geology in the 18th and 19th centuries.

The course deals with, although briefly, the history of the earth from the time of our Sun caught fire until now. Its emphasis is on historical processes, the succession of living systems and the interactions of both with the physical environment. Lectures and laboratory.

Prerequisites:
Geol. 212, Geol. 213 or permission of the department

Text: Oasis in Space: Earth History form the Beginning, Preston Cloud, N.W. Norton and Company, 508p.

Laboratory Exercises in Historical Geology, Walker, Broadhead, Bryan, Hunter Textbooks Inc.

Assignments & Grading:

Laboratory (lab reports and short papers)	40%
Written examinations	60%

GEOLOGY 332

ECONOMIC GEOLOGY (3 credits)

Professor: G.P. Sassano
Lec. 01 TJ 10:15-11:30 (Loyola)
Lab. 01 T 14:00-17:00 (Loyola)

Description: This course is designed for students having some basic notions of geology (see prerequisite). The course deals with the nature, origin, classification and economic evaluation of mineral deposits. Concepts related to the economics of the mining industry including the life cycle of a mining operation, the evaluation of natural resources, the calculation of reserves and economic analysis and profitability of mineral deposits will be studied. The course will also deal with concepts related to the chemicophysical and structural controls responsible for the formation of ore deposits, concepts of zonation and notions of metallogenic provinces and metallotects. Concepts related to reconnaissance, mapping, mineral exploration, geophysics and geochemistry, interpretation, will also be dealt with. Lectures and laboratory. Note: Students who have received credit for Geol. 412 may not take this course for credit.

Prerequisites: Geol. 311 previously or concurrently.

Texts: Exploration and Mining Geology, W.C. Peters, John Wiley & Sons.
Ore deposits, Park and MacDiarmid, Freeman.

Assignments & Grading: T.B.A.

GEOLOGY 411/3

IGNEOUS AND METAMORPHIC PETROLOGY (6 credits)

Professor: J.T. Jenkins
Lec. 01 TJ 11:45-13:00 (Loyola)
Lab. 01 W 14:00-17:00 (Loyola)

Description: Interpretation of phase diagrams. Mineralogy, fabric and petrogenesis of igneous and metamorphic rocks. Magmatic and metamorphic processes. ACF and AKF diagrams for various metamorphic facies. Study of selected problems. Lectures and laboratory.

Prerequisites: Geol. 311 and 313

Texts: a) Igneous Petrology: Hall, Anthony. Longman Scientific & Technical, 1987.
b) Petrogenesis of the Metamorphic Rocks, Winkler, H.G.F., 5th ed., Springer-Verlag, 1979.

Recommended References:
a) Ehler's, E.G. The interpretation of Geological Phase Diagrams. Freeman & Co., 1972.
b) Deer, Howie and Zussman An Introduciton to the Rock Forming Minerals (paper) 2nd ed., Longman's, 1992.
c) Ehlers, E.G., Optical Mineralogy, vol. 2. Mineral Descriptions. Blackwell, 1987.
d) Ness, W.D. Optical Mineralgoy, 2nd ed. Oxford Univ. Press, 1992.
e) Spry, A. Metamorphic Textures. Pergamon, 1969.

Assignments & Grading:

Weekly petrographic reports	34-45%
Test on Phase Equilibria	10%
Final exam	45-55%

GEOLOGY 413/4

SEDIMENTARY PETROLOGY (3 credits)

Professor: K.K. Mukherji
Lec. 01 WF 11:45-13:00 (Loyola)
Lab. 01 M 14;00-17:00 (Loyola)

Description: General principles of sediment diagenesis, followed by detailed analysis of the diagenetic evolution of sandstone, shale and carbonate rocks. Emphasis is placed heavily on the microscopic criteria in the recognition of diagenetic fabric. Problems of primary sedimentary structures and their hydrodynamic interpretation are also discussed. Specialized topics on current development in sedimentary lithogenesis are also included.

Prerequisites: Geol. 311 and 313

Texts: Sedimentology, Leeder, M.R., Allen and Unwin

Assignments & Grading:

Student must attend at least 80% of lecture and lab. sessions. Students must secure a clear passing grade in theory and lab portions separately.

Laboratory assignments	50%
Final exam	50%

Examination materials include lecture topics, handouts, special reading assignments.

GEOLOGY 414/3

UNDERGRADUATE RESEARCH (6 credits)

Professor: Staff

Description: Honours students in their final year are expected to show competence in isolating and examining a geological problem under the supervision of a faculty. A written application to take the course, including a brief outline of the research project, must be made to the Department before April 15 of the second year. The applicant will be reviewed by a committee and a decision forwarded by mail. The results of research must be presented in the form of an undergraduate thesis, two copies of which must be submitted by April 25.
Note: Written requests from Specialization students, with appropriate academic records, to take the course will be considered.

Prerequisite: Permission of the Department

GEOLOGY 415/4

PLATE TECTONICS AND CRUSTAL EVOLUTION (3 credits)

Professor: C. Elliott

Lec. 01 TJ 08:45-10:00 (Loyola)
Lab. 01 F 14:00-17:00 (Loyola)

Description: Techniques of data collection in tectonics. Structure and rheology of the upper mantle. Tectonics of crustal types to include shields, platforms, passive continental margins, Phanerozoic foldbelts, continental rifts, island-arc trench belts and oceanic rises. Sea-floor spreading plate tectonics, magma associations and plate reconstructions. Crustal origin and growth. Lectures and laboratory.
Note: Students who have received credit for Geol. 315 may not take this course for credits.

Prerequisites: Geol. 213, 231, 311

Texts: Global Tectonics, P. Keary and F.J. Vine. Blackwell Scientific Publications.

Assignments & Grading:

Lab reports and short papers	45%
Written examinations	55%

GEOLOGY 417/4

MINERAL DEPOSITS (3 credits)

Professor: Dr. G.P. Sassano

Lec. 01 TJ 10:15-11:30 (Loyola)
Lab. 01 T 14:090-17:00 (Loyola)

Description: This course is designed for students with a good background in economic geology. The course will deal with the study of geological processes related to the formation of ore deposits. It will thus study magmatic segregation, contact metasomatic, hydrothermal, sedimentary, submarine exhalative and volcanogenic processes. The course will also deal with residual, mechanical concentration, and supergene enrichment processes. Concepts of geothermometry, geobarometry and isotope studies will also be dealt with. Examples of geological settings from the most representative mining districts of the world will also be discussed. Laboratory includes examination and study by means of microscopy, fluid inclusions and microhardness tests of rock samples and ore suites from the most representative mining camps of the world. Lectures and laboratory.

Note: Students who have received credit for Geol. 416 may not take this course for credit.

Prerequisites: Geol. 332, 390 or Geol. 411 previously or concurrently.

Texts: Ore deposits, Park and McDiarmid, Freeman, Barnes, Wiley Interscience.

Geochemistry of Hydrothermal Ore deposits, Barnes, Wiley Interscience.

Ore Petrology, Stanton, McGraw-Hill

Ore Microscopy and Ore Petrology, Graig and Vaughan, Wiley Interscience.

Assignments & Grading: T.B.A.

GEOLOGY 498C/2

Environmental Change

Professor: J. Patterson Lec. A 11:45-14:30

Description: The purpose of the course is to examine current topics in environmental issues, with emphasis on the scientific aspects of these topics and how the science impacts on the public policy. The course will involve selected readings from current research published in major journals. Each week will focus on a specific topic, and the students will be expected to read selected papers prior to class. The class will consist of a directed discussion of the topic. At the beginning of the next class, a summary of the topic will be submitted. Each student will also prepare a term paper for submission at the end of the term, examining one subject area in detail. There will be no final exam.

The topics that will be covered:

- the role of the mantle in global biogeochemical cycles
- the carbon cycle
- ice cores and the record of atmospheric CO_2
- methane and climate
- the deep sea record of climate change through oxygen isotopes
- climate models; how good are the predictions?
- changes in stratospheric ozone chemistry
- tropical deforestation; climatic impacts
- population and global change
- what's wrong with nuclear energy?
- current trends in governmental policy

Prerequisites:

one of Geol. 210/Geog. 271/Geog. 275/Geog 276 or equivalent
one of Geol 331/Geog 372/Geog 373 or equivalent
or permission of the instructor

Assignments & Grading:

Course participation	35%
Weekly written assignments	35%
Term Paper	30%

GEOLOGY DEPARTMENT PROGRAMME - TIMETABLE 1994-95

FALL	Monday	Tuesday	Wednesday	Thursday	Friday
08.45-10:00		311/3-01 318/2-01	231/2-01	311/3-01 318/2-01	231/2-01
10:15-11:30		210/2-01 332/2-01	313/2-01	210/2-01 332/2-01	313/2-01
11:45-13:00	498C/4	411/3-1	314/2-01	411/3-01	314/2-01
13:15-14:30	224-01		224-01		
15:00-18:00	224-01 Lab.				
LABS 14:00 TO 17:00	314-01	210-01 332-01	411-01	313-01 318-01 231-01	311-01
18:05-20:10			208-XX		
LABS 18:30-21:30					
19:00-21:05	203-51				

GEOLOGY DEPARTMENT PROGRAMME-TIMETABLE 1994-95

WINTER	Monday	Tuesday	Wednesday	Thursday	Friday
08:45- 10:00		311/3-01 415/4-01	331/4-01	311/3-01 415/4-01	331/4-01
10:15- 11:30		417/4-01	211/4-01	216/4-01 417/4-01	211/4-01
11:45- 13:00		212/4-01 411/3-01	213/4-01 413/4-01	212/4-01 411/3-01	213/4-01 413/4-01
13:15- 14:30					
LABS. 14:00 TO 17:00	211-01 413-01	212-01 417-01	411-01	213-01 331-01	311-01 415-01
18:05- 20:10		232/4-51		205/4- XX	
LABS 18:30- 21:30		210-51	232-51		
19:00- 21:05	210/4-51		206/4-51	298/4-51	